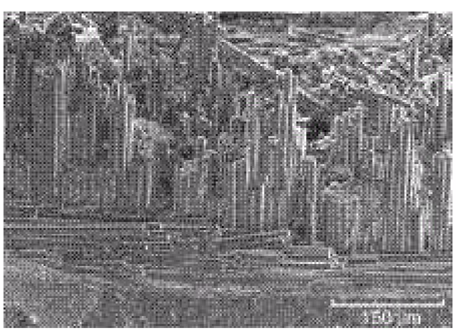
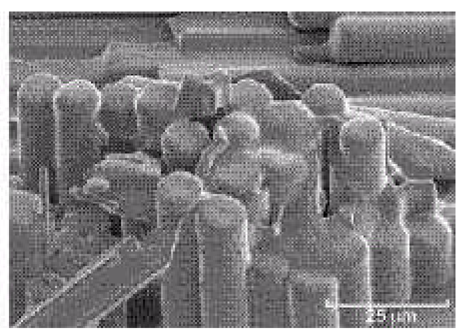
Creep/Rupture Behavior of Melt-Infiltrated SiC/SiC Composites Being Investigated

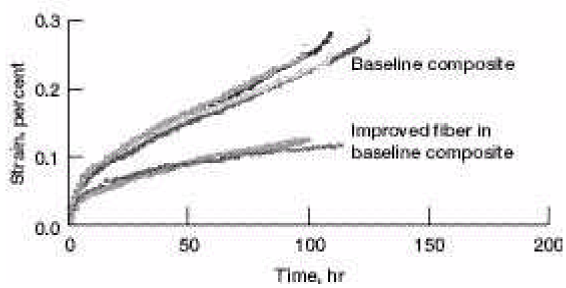
The failure behavior of melt-infiltrated SiC/SiC ceramic matrix composites is under investigation at the NASA Glenn Research Center as part of NASA's Ultra-Efficient Engine Technology Program. This material was originally developed under the High Speed Research Office's Enabling Propulsion Materials Program. Creep and rupture data provide accelerated testing information to predict material behavior under engine use situations (1500 to 2400 °F). This information gives insights into various material development paths to improve composites as well as improve understanding of failure mechanisms.

The left figure shows the fracture surface of a CMC material following over 200 hr of testing at 2400 °F. This surface demonstrates the kind of fibrous pullout desirable for maximum crack deflection, hence nonbrittle failure. Microscopy suggests that creep and rupture of these materials can best be considered as a probabilistic property, rather than a material property. Fiber failure occurs first in isolated regions, while stronger adjacent fibers remain intact. The right figure shows a region where oxide deposits blur and round the fiber images. Because the oxidation kinetics of SiC are well understood, this oxide scale can be used as a measure of the length of time various regions of the composites have been exposed to the environment, hence providing vital information regarding the sequence of failure. The oxide scale in the right figure indicates an early failure of this tow of fibers, whereas adjacent tows remain oxide free, suggesting failure much later in time. The path of various cracks can be followed throughout the composite in this manner, suggesting failure mechanisms.

Remote, noncontact strain-sensing system. Left: Typical fibrous fracture surface of a nonbrittle composite. Right: Isolated oxide scale formed during creep.

Most CMC applications require stringent dimensional tolerance. In addition, excessive amounts of creep strain have been shown to degrade material strength. Current work has demonstrated that improvements to the reinforcing fiber have been shown to dramatically improve creep behavior as shown in the graph.



Improved creep and rupture behavior can be achieved by altering the reinforcing fiber phase. Temperature, 1315 °C; pressure, 15 ksi.

Creep and rupture testing are providing guidance for ongoing improvements to the high-temperature thermomechanical behavior of SiC/SiC composites as well as fundamental understanding of the failure mechanisms involved in these materials.

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